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I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND
SALES hereby certify that annexed is a true copy of the Provisional specification
in connection with Application No. 2003904385 for a patent by MURDOCH
UNIVERSITY as filed on 18 August 2003.



WITNESS my hand this
Twenty-fifth day of August 2004

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ORIGINAL
AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: "Improved Thiosulphate Leach Process"

The invention is described in the following statement:

"Improved Thiosulphate Leach Process"

Field of the Invention

The present invention relates to an improved thiosulphate leach process. More particularly, the thiosulphate leach process of the present invention is intended
5 for use in the extraction of gold from ores or other gold-bearing materials using thiosulphate as a lixiviant in the absence of ammonia/ammonium and copper ions.

Background Art

The process of alkaline cyanidation for the extraction of gold from its ores has
10 been practiced for over a century and remains the predominant method world wide in gold production. Despite its proven records, there have been increasing concerns in the community over the high toxicity of cyanide, which poses serious health and environmental risks. In fact, some countries have now banned the construction of new cyanidation plants. Under these circumstances, alternative
15 non-toxic lixivants for the extraction of gold have been investigated, including the use of a thiosulphate lixiviant.

In a thiosulphate solution containing an oxidant such as dissolved oxygen, gold may be dissolved as the gold-thiosulphate complex according to the following
20 reaction:



Although the reaction is favoured thermodynamically, the rate at which gold
25 dissolves is very slow unless a catalyst is present. This is thought to be the result of: (i) Oxygen is not an effective oxidant because of its slow reduction on the gold surface. (ii) The dissolution of gold is hindered because of the passivation of the gold surface in the thiosulphate solution.

In order to obtain a reasonably fast leaching rate, it is generally understood that ammonia and copper ions are required in the thiosulphate solution under alkaline conditions (e.g. pH > 9). Ammonia, usually added as the ammonium thiosulphate salt, helps stabilise the copper as the copper(II) tetrammine complex
5 which serves as an effective oxidant. Presumably the copper(II) tetrammine is regenerated by dissolved oxygen. In addition, it has been shown that both ammonia and copper may have catalytic effect on the half reaction of gold oxidation. This process is described in, for example, US Patent 4269622 (Kerley, Jr.), US Patent 4369061 (Kerley Jr.) and US Patent 4654078 (Perez et
10 al.).

There are several substantial drawbacks associated with the ammonia- copper-thiosulphate leaching process. Firstly, copper is known to catalyse the oxidation of thiosulphate. This not only results in very high reagent consumption, but also
15 generates significant amounts of polythionates which may be detrimental to the down-stream gold recovery process. Secondly, the process is not robust, with the leaching conditions having to be controlled very carefully and often ore-specifically. Thirdly, concerns have been raised over the widespread use of ammonia in fairly large concentrations, which may be a potential hazard to the
20 environment. For these reasons, no commercial applications of the ammonia-copper-thiosulphate process have yet been implemented.

The preceding discussion of the background art is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material
25 referred to was part of the common general knowledge in Australia as at the priority date of the application.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the
30 exclusion of any other integer or group of integers.

Disclosure of the Invention

In accordance with the present invention there is provided an improved thiosulphate leach process, the process comprising the method steps of submitting a gold-bearing material to a leach in a thiosulphate solution, wherein
5 thiourea and at least one oxidant are present in the thiosulphate leach solution, and recovering gold from the resulting pregnant leach solution.

Preferably, thiourea is provided in a concentration of about 0.01 mole/L.

Preferably, the oxidant present is a complex of ethylenediaminetetraacetate (EDTA) with a multivalent metal. The multivalent metal may be iron and the
10 complex FeEDTA.

Still preferably, thiosulphate is added in the form of a soluble salt. In one form of the present invention the soluble salt is the sodium salt of thiosulphate.

In one form of the present invention thiosulphate is provided in a concentration of about 0.1 to 0.3 mole/L.

15 The preferred oxidant FeEDTA may be prepared prior to addition to the leach solution or it may be prepared by adding suitable amounts of iron salts and EDTA directly to the leach solution.

Preferably, the concentration of FeEDTA in the leach solution is about 0.002 mole/L.

20 In accordance with the present invention there is further provided an improved thiosulphate leach process for the recovery of gold from ores and other gold-bearing materials, the leach solution comprising thiosulphate, thiourea and an oxidant that does not oxidise thiosulphate, the process producing a pregnant leach solution from which gold may be recovered.

Preferably, the oxidant present is a complex of ethylenediaminetetraacetate (EDTA) with a multivalent metal. The multivalent metal may be iron and the complex FeEDTA.

The FeEDTA may be provided at a concentration of about 0.002 mole/L.

- 5 Still preferably, the thiosulphate is provided at a concentration of 0.1 to 0.3 mole/L. Further, thiourea is preferably provided at a concentration of 0.01 mole/L.

In one form of the present invention gold is recovered from the pregnant leach solution by way of either cementation or ion exchange.

10 **Best Mode(s) for Carrying Out the Invention**

- The process of the invention involves the leaching of gold using a solution containing thiosulphate, thiourea and an effective oxidant. The oxidant is provided in the form of an EDTA complex with a multivalent metal, for example iron which provides the complex FeEDTA. Thiosulphate can be added as the sodium salt or any other soluble salt of thiosulphate. The preferred concentration of thiosulphate is 0.1 – 0.3 mole/L, but lower or higher concentrations can also be used, in the range of 0.02 to 1 mole/L. The role of thiourea is to catalyse the half reaction of gold oxidation. The preferred concentration of thiourea is 0.01 mole/L though higher or lower concentrations are also applicable, the range of 0.002 to 0.1 mole/L.
- 15
20

An oxidant is essential for the leaching of gold and one of the least expensive oxidant is dissolved oxygen. However, oxygen alone is not sufficient to extract gold effectively in such a system. A practical thiosulphate leaching system requires an oxidant that:

25

1. Has a reduction potential in excess of about 0.2 V;
2. Does not oxidise thiosulphate;
3. Can be preferably re-oxidised by oxygen; and

4. Is not too expensive.

An example of such an oxidant is FeEDTA. The oxidant can be prepared prior to the leaching by mixing a ferric salt, such as ferric nitrate or ferric sulphate, in a solution with EDTA. Alternatively, it can be prepared using a ferrous salt in the presence of dissolved oxygen using the same procedure. The ferrous EDTA complex formed is then oxidised to FeEDTA by the dissolved oxygen. It is also possible to prepare the FeEDTA by adding suitable amounts of iron salts and EDTA directly to the leaching slurry where the complex is formed *in-situ*. The concentration of the FeEDTA is preferably as low as 0.001 mole/L, but is preferably 0.002 mole/L, to minimise the cost. It is envisaged that higher concentrations, up to 0.01 mole/L, may result in better kinetics and gold recoveries.

Ideally the leaching is carried out in neutral pH and at ambient temperature (understood to mean between about 20-30°C) and over a period of up to 48 to 72 hours. The preferred pH range for the leaching is pH 5-9. The leaching may also be performed at higher pHs but thiourea may slowly decompose at such conditions. Similarly, the leaching may be conducted at elevated temperatures although gold recovery may be inversely affected by the increase in temperature. Temperatures of up to about 50°C are envisaged for ores, whilst higher temperatures may be employed with concentrates.

The process described is simple and provides leaching kinetics comparable to known cyanidation processes. Another important advantage is that the FeEDTA oxidant oxidises only gold and not thiosulphate. As a result, the reagent consumption is low in contrast to the relatively heavy loss of thiosulphate associated with the ammonia-copper-thiosulphate leaching process. After leaching, the gold in the pregnant solution can be recovered using the techniques which have been proposed for the ammonia-copper-thiosulphate process, such as cementation or ion exchange.

The improved thiosulphate leach process of the present invention will now be described with reference to several non-limiting examples:

EXAMPLE 1

5 Gold powder, as prepared by reduction precipitation from a AuCl_4^- solution, was leached using an oxygenated sodium thiosulphate solution (0.1 mole/L) containing thiourea (0.01 M) at pH 6 and the ambient temperature. The leach was run for 96 hours in a stirred reactor with 19.4 ppm gold dissolved (69.3% recovery). For comparison, only 3.6 ppm gold was dissolved (18.4%) in the
10 absence of thiourea. These results show that the addition of thiourea catalyses the oxidation of gold but, on the other hand, oxygen alone is insufficient for satisfactory leaching kinetics for practicable gold plant operation (typically 24 —48 hours maximum leach times) and gold recovery.

15 EXAMPLE 2

An ore sample (Ore 1) obtained from a cyclone overflow was used for the leaching tests using the improved process of the present invention, at a grind size of 75% passing 75 μm . This ore contains about 2 kg/t gold in average. The
20 leaching conditions are outline below:

	Sodium thiosulphate concentration:	0.3 mole/L
	Thiourea concentration:	0.01 mole/L initially and extra 0.01 mole/L was added after 8 hours
25	FeEDTA concentration:	0.003 mole/L initially and extra 0.002 mole/L was added after 8 hours
	Slurry pulp density:	40% (wt.)
	pH range:	6.5 – 8
	Temperature:	Ambient
30	Leaching time:	24 hours

The gold recovery was 88-90%.

EXAMPLE 3

An ore sample (Ore 1) collected from cyclone underflow, was ground and screened and the portion with particle sizes of $-150\text{ }\mu\text{m}$ was used for the leaching tests. The average grade of gold is about 17.4 g/t. The leaching conditions were:

	Sodium thiosulphate concentration:	0.3 mole/L
10	Thiourea concentration:	0.01 mole/L initially and extra 0.01 mole/L was added after 8 hours
	FeEDTA concentration:	0.003 mole/L initially and extra 0.002 mole/L was added after 8 hours
	Slurry pulp density:	40% (wt.)
	pH range:	6.5 - 8
15	Temperature:	Ambient
	Leaching time:	24 hours

Gold recoveries of 92.5-97.5% were achieved using the above specified leaching conditions.

EXAMPLE 4

An ore sample (Ore 2) was obtained containing 2.5 g/t gold, sized as 100% passing $150\text{ }\mu\text{m}$. The thiosulphate leaching tests were performed under the following conditions:

	Sodium thiosulphate concentration:	0.3 mole/L
	Thiourea concentration:	0.01 mole/L
	FeEDTA concentration:	0.003 mole/L
30	Slurry pulp density:	40% (wt.)
	pH range:	6.5 - 8.5
	Temperature:	ambient

Leaching time:

24 hours

The recovered values of gold after leaching under such conditions are typically 89.6-98%.

5

Modifications and variations such as would be apparent to a skilled addressee are considered to fall within the scope of the present invention.

Dated this Eighteenth day of August 2003.

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